

WHAT IS CLAIMED IS:

1 1. An identification system comprising:
2 a plurality of identifiable elements;
3 a plurality of labels, each label associated with a unique or non-unique
4 identifiable element, the labels including reference markers and other markers, the labels
5 generating spectra in response to excitation energy; and
6 an analyzer for identifying the elements from the spectra of the associated
7 labels, the analyzer calibrating the spectra using reference signals generated by the
8 reference markers.

1 2. The identification system of claim 1, wherein the labels comprise
2 semiconductor nanocrystals.

1 3. The identification system of claim 2, wherein each reference
2 marker comprises at least one reference semiconductor nanocrystal.

1 4. The identification system of claim 3, wherein the reference markers
2 comprise a plurality of reference semiconductor nanocrystals, the reference markers of
3 each label generating a reference signal at a reference wavelength with a reference
4 intensity.

1 5. The identification system of claim 4, wherein the other markers
2 comprise other semiconductor nanocrystals generating other signals at other wavelengths
3 and with other intensities.

1 6. The identification system of claim 1, wherein the other markers
2 comprise code signal markers which generate code signals different than the reference
3 signals, the spectra comprising the marker signals and the code signals, and wherein, for
4 at least one label, the analyzer discretely quantifies the code signals emitted by the code
5 signal markers of the label by comparison of the code signals with the reference signal
6 and by selecting signal characteristics of the code signals from among a plurality of
7 discrete, predetermined signal characteristics.

1 7. The identification system of claim 6, wherein the reference signal
2 of each label has a reference intensity, and wherein the code signals of the label have

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3 code signal intensities, the analyzer discretely quantifying the code signal intensities by
4 comparison to the reference intensity of the label.

1 8. The identification system of claim 7, wherein the code signal
2 intensities define discrete ratios with the associated reference intensities.

A 1 9. The identification system of claim 7, wherein, for each label, the
2 reference intensity comprises at least one member selected from a group consisting of: a
3 highest intensity of the spectra, a lowest intensity of the spectra, a shortest wavelength
4 peak of the spectra, and a longest wavelength peak.

1 10. The identification system of claim 1, wherein at least some of the
2 reference signals of the labels have common reference wavelengths.

1 11. The identification system of claim 1, where the reference signals of
2 at least some of the labels have different reference wavelengths.

1 12. The identification system of claim 11, wherein each reference
2 signal has a reference wavelength, the reference wavelength being a shortest or a longest
3 wavelength of the spectra of the label.

1 13. The identification system of claim 1, wherein the reference signals
2 have reference wavelengths, and wherein the other signals have other wavelengths, the
3 other wavelengths of each label being discretely quantifiable by reference to the reference
4 wavelength of the label.

1 14. The identification system of claim 1, wherein the spectrum of a
2 first label comprises signals having a plurality of wavelengths, wherein a spectrum of a
3 second label comprises signals having the plurality of wavelengths, and wherein the
4 analyzer calibrates spectra intensities of the first and second labels based on the reference
5 signals to distinguish the first and second labels.

1 15. The identification system of claim 1, further comprising at least
2 1000 labels with associated identifiable elements.

1 16. The identification system of claim 1, further comprising fewer than
2 1000 label with associated identifiable elements.

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1 17. The identification system of claim 1, wherein the analyzer
2 comprises a tangible media embodying a machine readable code, the code comprising a
3 listing of a plurality of distinguishable labels.

1 18. The identification system of claim 17, wherein the code further
2 comprises a listing of identifiable elements and a correlation between each
3 distinguishable label and an associated identifiable element having the distinguishable
4 label.

1 19. The identification system of claim 1, wherein the identifiable
2 elements comprise at least one member selected from the group consisting of a
3 composition of matter, a fluid, an article of manufacture, a consumer product, and a
4 component for an assembly.

1 20. A method for sensing a plurality of identifiable elements, the
2 method comprising:
3 labeling each identifiable element with a reference marker and at least one
4 associated other marker;
5 energizing the markers of a first label from a first identifiable element so
6 that the markers generate signals;
7 measuring a spectrum of the signals; and
8 identifying a first identifiable element from the spectrum by calibrating the
9 spectrum with reference to a reference signal from the reference marker of the first label.

1 21. A library of elements, the library comprising:
2 a plurality of identifiable elements, each identifiable element having an
3 associated label with a reference marker, the labels generating spectra in response to an
4 excitation energy, each spectrum including a spectral calibration reference signal from the
5 reference marker.

1 22. The library of claim 21, wherein the labels comprise semiconductor
2 nanocrystals.

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1 23. The library of claim 22, wherein the semiconductor nanocrystals
2 generate the signals in response to the excitation energy, each reference marker
3 comprising at least one reference semiconductor nanocrystal.

1 24. The library of claim 23, wherein at least some of the labels
2 comprise at least one other semiconductor nanocrystal generating another signal at
3 another wavelength in response to the excitation energy, the other wavelength different
4 than a reference wavelength of the reference signal.

1 25. The library of claim 22, wherein at least some of the labels
2 comprise other markers associated with the reference marker, the other markers
3 generating other signals in response to the excitation energy, the other signals differing
4 from the associated reference signals, and discretely quantifiable by comparison of the
5 other signals with the associated reference signals.

1 26. The library of claim 25, wherein the reference signals have
2 reference intensities, and wherein the other signals have other intensities, the other
3 intensities each being discretely quantifiable by comparison to the associated reference
4 intensity.

1 27. The library of claim 26, wherein ratios defined by the other
2 intensities to the associated reference intensities define discrete intensity ratio increments.

1 28. The library of claim 25, wherein, for each spectrum, the reference
2 intensity is a highest intensity of the spectrum or a lowest intensity of the spectrum.

1 29. The library of claim 25, wherein at least some of the labels have a
2 first other intensity higher than the reference intensity, and a second other intensity lower
3 than the reference intensity.

1 30. The library of claim 25, wherein, for each label, the reference
2 signal has a reference wavelength, the reference wavelength being a shortest or a longest
3 wavelength of the spectra of the label.

1 31. The library of claim 25, wherein the reference signals have
2 reference wavelengths and the other signals have other wavelengths, at least some of the

3 labels including a first other wavelength shorter than the reference wavelength of the
4 label, and a second other wavelength longer than the reference wavelength of the label.

1 32. The library of claim 25, where the reference signals of at least
2 some of the labels have differing reference wavelengths.

1 33. The library of claim 25, wherein at least some of the reference
2 signals of the labels have common reference wavelengths.

1 34. The library of claim 25, wherein the reference signals of the labels
2 have differing reference wavelengths.

1 35. The library of claim 21 wherein the spectrum of a first label
2 comprises signals having a plurality of wavelengths, wherein a spectrum of a second label
3 comprises signals having the plurality of wavelengths, the first and second spectra having
4 differing overall intensities, the first and second labels distinguishable by calibration of
5 the first and second spectra based on intensities of the reference signals of the first and
6 second signals, respectively.

1 36. The library of claim 21, further comprising at least 1000
2 differentiable labels.

1 37. The library of claim 21, further comprising fewer than 1000
2 differentiable labels.

1 38. The library of claim 21, further comprising a tangible media
2 embodying a machine readable code, the code comprising a listing of the labels.

1 39. The library of claim 38, wherein the code further comprises a
2 listing of identifiable elements and a correlation between each label and an associated
3 identifiable element having the label.

1 40. The library of claim 21, wherein the identifiable elements comprise
2 at least one member selected from the group consisting of a composition of matter, a
3 fluid, an article of manufacture, a consumer product, a bead, and a component for an
4 assembly.

1 41. A method comprising:

2 labeling an identifiable element with a label;
3 measuring a spectrum generated by the label, the spectrum comprising a
4 plurality of signals; and
5 identifying the element by selecting a first wavelength range
6 encompassing a first signal of the spectra, and by determining a wavelength of the first
7 signal within the first range.

A' 1 42. The method of claim 41, wherein the element is labeled by
2 applying at least one semiconductor nanocrystals to the element, the semiconductor
3 nanocrystals generating at least some of the signals in response to excitation energy.

1 43. The method of claim 41, further comprising selecting a second
2 wavelength range encompassing a second signal of the spectra, and by determining a
3 wavelength of the second signal within the second range.

1 44. The method of claim 43, further comprising, for each other signal
2 of the spectra, selecting another wavelength range encompassing the other signal and
3 determining a wavelength of the other signal, wherein no more than one signal of the
4 spectra is disposed within each wavelength range.

1 45. The method of claim 43, wherein the wavelengths of the first and
2 second signals are determined by selecting the wavelengths of the signals from a plurality
3 of discrete wavelengths within the ranges

1 46. The method of claim 45, wherein the discrete wavelengths within
2 each range are sufficiently close that two signals at adjacent discrete wavelengths within
3 the range would substantially overlap.

1 47. The method of claim 45, wherein the discrete wavelengths within
2 the ranges are predetermined.

1 48. The method of claim 45, wherein the discrete wavelengths within
2 the ranges are separated by about 5 nm or more.

1 49. The method of claim 45, wherein the discrete wavelengths within
2 the ranges are separated by about 30 nm or more.

1 50. The method of claim 45, wherein the ranges are separated.

1 51. The method of claim 50, wherein the ranges are sufficiently
2 separated so that a pair of signals at adjacent discrete wavelengths within adjacent
3 wavelength ranges are sufficiently separated for independent identification of the discrete
4 wavelengths of each signal of the pair.

1 52. The method of claim 50, wherein the ranges are separated by more
2 than about 30 nm.

1 53. The method of claim 50, wherein each wavelength range includes
2 at least 5 predetermined discrete wavelengths.

1 54. The method of claim 53, wherein there are at least three non-
2 overlapping wavelength ranges.

1 55. The method of claim 41, further comprising identifying a plurality
2 of elements in response to spectra generated from other labels associated with the
3 elements by selecting wavelength ranges encompassing signals of the spectra, and by
4 determining wavelengths of the signals within the ranges.

1 56. The method of claim 55, wherein no more than one signal from
2 each spectrum is disposed within each wavelength range.

1 57. The method of claim 55, further comprising establishing
2 predetermined wavelength ranges, the plurality of elements being identified using the
3 predetermined wavelength ranges.

1 58. The method of claim 57, further comprising establishing
2 predetermined discrete wavelengths within the predetermined wavelength ranges, the
3 wavelengths of the signals being selected from the predetermined wavelengths.

1 59. The method of claim 55, further comprising rejecting labels having
2 excessive overlap between adjacent discrete wavelengths from different adjacent
3 wavelength ranges.

1 60. The method of claim 55, wherein the wavelength determining step
2 comprises a binary determination between a presence of the discrete wavelength and an
3 absence of the discrete wavelength.

1 61. The method of claim 60, wherein the spectra of the labels comprise
2 a plurality of separated luminescent signals including signals within the first range, the
3 first range being predetermined, and a second predetermined wavelength range, a discrete
4 wavelength of at least one of the signals of each spectrum being different than a discrete
5 wavelength of the spectrum of every other spectrum.

1 62. The method of claim 55, further comprising measuring a discrete
2 intensity of the discrete wavelength.

1 63. The method of claim 55, wherein the label and the other labels
2 comprise intermingled markers.

1 64. The method of claim 63, wherein the signals of a first label are
2 encompassed within the first predetermined wavelength range, and wherein the signals of
3 a second label are encompassed within another wavelength range such that the spectra of
4 the first and second labels are separated.

1 65. A method for sensing a plurality of intermingled labels, the method
2 comprising:
3 energizing the labels so that the labels generate signals;
4 identifying a first label by measuring a first discrete wavelength from
5 among a plurality of discrete wavelengths within a first wavelength range; and
6 identifying a second label by measuring a second discrete wavelength from
7 among a plurality of discrete wavelengths within a second wavelength range, the first and
8 second ranges being separated.

1 66. The method of claim 65, further comprising adding a plurality of
2 labels to a fluid at an associated plurality of process steps so that the labels indicate the
3 process steps performed to the fluid.

1 67. An inventory system comprising:
2 a plurality of identifiable elements; and

3 a plurality of labels having markers, each label associated with an element,
4 each marker generating a signal when energized so that each label emits an identifiable
5 spectrum, at least some of the spectra comprising a plurality of the signals, each signal of
6 the spectra having a discrete wavelength selected from within a dedicated wavelength
7 range, the ranges sufficiently separated so that the signals in different ranges are
8 independently identifiable.

1 68. The inventory system of claim 67, further comprising an analyzer
2 having a signal sensor in optical communication with the signals and a processor, the
3 processor selecting a first discrete wavelength from among a plurality of discrete
4 wavelengths within a first wavelength range in response to a first signal of a first spectra,
5 the processor selecting a second discrete wavelength from among a plurality of adjacent
6 discrete wavelengths within a second wavelength range, the first and second ranges being
7 separated, the processor having a database of the identifiable elements and the associated
8 labels and generating an element identification signal in response to the first and second
9 selected wavelengths.

1 69. The inventory system of claim 68, wherein the labels comprises at
2 least one bead including a matrix, the markers including at least one semiconductor
3 nanocrystal supported in the matrix.

1 70. The inventory system of claim 67, wherein each label comprises at
2 least one bead, and wherein at least some of the beads have a plurality of markers
3 comprising an associated plurality of semiconductor nanocrystal populations, each
4 population including a plurality of semiconductor nanocrystals that emit a substantially
5 uniform wavelength when energized so as to define the signal of the marker.

1 71. The inventory system of claim 67, wherein each label has a unique
2 spectra including no more than one discrete wavelength selected from a plurality of
3 predetermined wavelengths within each of a plurality of separated wavelength ranges.

1 72. An inventory label generating method comprising:
2 generating a plurality of candidate labels; and
3 selecting a plurality of acceptably distinguishable labels from among the
4 candidate labels by determining spectra emitted by the candidate labels when the
5 candidate labels are energized, and by comparing the spectra of the candidate labels.

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1 73. The method of claim 72, wherein the labels comprise
2 semiconductor nanocrystals.

1 74. The method of claim 72, wherein the candidate labels are generated
2 by combining a plurality of markers, each marker emitting a marker signal at an
3 associated signal wavelength in response to excitation energy.

1 75. The method of claim 72, further comprising directing an excitation
2 energy toward the markers and measuring the spectra emitted by the labels.

1 76. The method of claim 72, wherein the spectra of the candidate labels
2 are determined by modeling a combination of a plurality of marker signals.

1 77. The method of claim 76, further comprising calculating at least one
2 of the signals by modeling emissions from a manufacturable marker.

1 78. The method of claim 77, further comprising adjusting the
2 calculated signals from the manufacturable marker in response to measured marker signal
3 variations.

1 79. The method of claim 76, further comprising measuring at least one
2 of the signals by energizing a marker so that the marker emits the signal.

1 80. The method of claim 72, further comprising comparing at least
2 some of the candidate labels with a library of distinguishable labels to determine if the
3 candidate labels are acceptable, and adding acceptable candidate labels to the library.

1 81. A method for identifying a plurality of identifiable elements, the
2 method comprising:

3 energizing a plurality of labels so that a first marker of each label
4 generates a first signal with a first wavelength peak, at least some of the labels comprising
5 multiple-signal labels, each multiple-signal label having a second marker generating a
6 second signal with a second wavelength peak;

7 measuring the first wavelength peaks;

8 for each multiple-signal label, measuring the second wavelength peak at at
9 least a predetermined minimum wavelength separation from the associated first peak; and

